(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 989 585 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
29.03.2000 Bulletin 2000/13

(51) Int Cl.[7]: H01J 49/04

(21) Application number: 99307233.9

(22) Date of filing: 13.09.1999

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: 24.09.1998 US 160502

(71) Applicant: FINNIGAN CORPORATION
San Jose, CA 95134-1991 (US)

(72) Inventors:
- Mylchreest, Iain C.
  Gilroy, California 95020 (US)
- Tang, Kegl
  Cupertino, California 95014 (US)

(74) Representative:
Cross, Rupert Edward Blount et al
BOULT WADE TENNANT,
27 Furnival Street
London EC4A 1PQ (GB)

(54) An assembly for coupling an ion source to a mass analyzer

(57) An ion transmission system for transferring ions from an atmospheric pressure ionization source to an analyzer including a capillary having an input orifice which is indirectly coupled to the ion source.

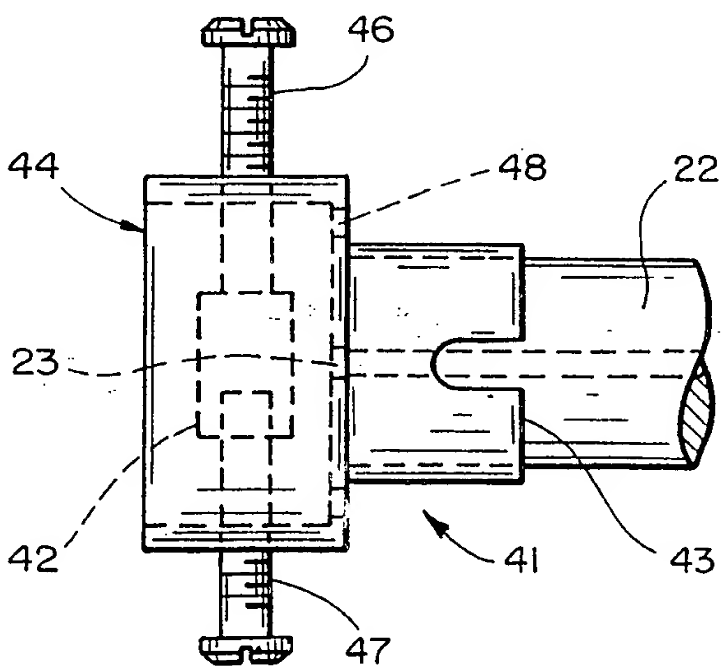

FIG_2

EP 0 989 585 A2

Description

Brief Description of the Invention

[0001] This invention relates generally to an atmospheric pressure ion source connected to a mass analyzer by an ion transfer assembly which includes a capillary passage, and more particularly to a capillary having a sample orifice which is not in the line of sight of the ion source.

Background of the Invention

[0002] U.S. Patent 5,157,260 shows a quadrupole mass filter coupled to an atmospheric pressure ion source by an ion transmission arrangement including a capillary, a conical skimmer and ion optics. A tube lens cooperates with the end of the capillary to force the ions into the center of the ion jet which travels through the conical skimmer. A quadrupole mass filter analyzes the transmitted ion beam to provide a mass spectrum.

[0003] U.S. Patent No. 4,542,293 describes a capillary made of an electrical insulator for conducting ions out of the ionizing electrospray region at atmospheric pressure to a lower pressure region. A conductive coating is formed on the ends of the capillary and a voltage is applied thereacross to accelerate the ions. A skimmer is disposed adjacent the end of the capillary and is maintained at a voltage which causes further acceleration of the ions through the skimmer and into a lower pressure region which includes focusing lenses and analyzing apparatus.

[0004] In these and other prior art mass analysis systems, the orifice of the capillary passage which connects the atmospheric pressure chamber to a lower pressure chamber is in line with the outlet of the ion spray device which forms the sample ions for analysis. This arrangement provides excellent performance for the majority of solvent systems and flow regimes used in atmospheric pressure ion (API) analysis. However, when non-volatile buffer systems are used, there is the possibility of fouling of the capillary intake or sampling orifice by deposition of salts from undesolvated droplets that strike the sampling orifice and evaporate. The deposited salts gradually block the flow of sample ions and reduce performance of the overall system by progressively reducing the number of ions which are transmitted to the mass analyzer.

Objects and Summary of the Invention

[0005] It is an object of the present invention to provide a capillary in which its sampling orifice is out of line of sight of the ion source.

[0006] It is another object of the present invention to provide an assembly for coupling an atmospheric pressure ion source to a mass analyzer which includes a capillary with a sampling orifice and an adaptor for indirectly coupling the sampling orifice to the ion source output such that fouling of the orifice is minimized.

[0007] The foregoing and other objects of the invention are achieved in a ion transmission assembly which couples an atmospheric pressure ion source to a mass analyzer by an assembly including a capillary having a sampling orifice opposite the ion source and an adaptor mounted on the sampling end of the capillary for indirectly coupling the orifice to the ion source output.

Brief Description of the Drawings

[0008] The foregoing and other objects of the invention will be more clearly understood from the description to follow when read in conjunction with the accompanying drawings of which:

Figure 1 shows an atmospheric pressure ion source coupled to a mass analyzer with an ion transmission assembly in accordance with the prior art.
Figure 2 is an enlarged view of a capillary adaptor assembly in accordance with one embodiment of the present invention.
Figure 3 is a front view of the adaptor of Figure 2.
Figure 4 is a rear view of the adaptor of Figure 2.
Figure 5 is an enlarged sectional view of a capillary with another type of adaptor indirectly coupling the capillary input orifice to the ion source.
Figure 6 is an end view of the adaptor of Figure 2.
Figure 7 is an end view of still another adaptor.
Figure 8 is an end view of a slotted adaptor.
Figure 9 is a side view of the slotted adaptor of Figure 8.
Figure 10 is a side view of an adaptor having a bent tube.

Description of Preferred Embodiment

[0009] Referring to Figure 1, an atmospheric pressure ion source 11 is schematically shown coupled to a mass analyzer 12 by an ion transmission assembly. The ion source may comprise an electrospray ion source or corona discharge ion source. The ion source forms an ion spray 13. The ionization mechanism involves the desorption at atmospheric pressure of ions from the fine electrically charged particles formed by an electrospray source or a corona discharge source. The ion spray 13 may include undesolvated droplets particularly when non-volatile sample buffers are used.

[0010] The ion transmission assembly includes successive chambers 16, 17 and 18, maintained at successively lower pressures, with the mass analyzer 12 in the lowest pressure chamber. The first chamber 16 communicates with the atmospheric pressure ionization chamber 21 via a capillary tube 22. Due to the differences in pressure, ions and gas are caused to enter the orifice 23 of the capillary tube, and flow through the capillary passage into the chamber 16. A voltage is applied be-

tween conductive sleeves 24 and 26 at the ends of the non-conducting capillary tube to provide a voltage gradient which accelerates the charged ions.

[0011] The other end of the capillary is opposite a skimmer 31 which separates the chamber 16 from the chamber 17 which houses octopole lens 32. The skimmer includes a central orifice or aperture 33 which may be aligned with the axis of the bore of the capillary, or the capillary bore may be slightly off axis to reduce neutral noise as described in U.S. Patent No. RE 35,413. A tube lens 36 cooperates with the end of the capillary to force ions into the center of the ion jet which leaves the capillary and travels through the skimmer 31. The octopole lens 32 is followed by ion optics which may comprise a second skimmer 34 and lens 35, which direct ions into the analyzing chamber 18 and into a suitable mass analyzer 12. The combination of capillary tube 22, skimmer 31, lens 32, skimmer 34 and lens 35 form the ion transmission assembly.

[0012] As described above, the entry orifice 23 of the capillary passage may be fouled by the deposition of salts from spray droplets and involatile material which strike the entrance orifice of the capillary and evaporate. The fouling is minimized in the present invention by indirectly coupling the sampling orifice to the ion source output so that it is no longer in the line of sight of the liquid droplets and involatile materials from the ion spray 13. An adaptor placed at the sampling end of the capillary prevents direct entry of the droplets and involatile material into the entrance orifice. The adaptor located at the entrance end of the capillary enables the indirect flow of ions into the sampling orifice. That is the orifice is not in direct line of sight of the ion source.

[0013] The preferred embodiment shown in Figures 2-4 includes an adaptor 41 which supports a disk 42 opposite the capillary orifice 23. The disk prevents line of sight liquid and involatile material from impinging directly on the orifice. Consequently, sample ions are indirectly coupled from the ion source to the capillary orifice 23. The adaptor 41 includes a collar 43 which is inserted over the end of the capillary. The end of the collar 43 engages the cup-shaped support 44. Suitable support means such as screws 46,47 engage and support the disk 42. The bottom of the cup-shaped support 44 includes slots 48 which allow the liquid droplets and involatile materials to be diverted away or past the orifice 23. The desolvated ions pass around the outer edges of the disk 42 and into the axial capillary passages as a result of the pressure differential between the atmospheric chamber 21 and the lower pressure chamber 16. The adaptor prevents liquid droplets and involatile material build-up a the orifice 23.

[0014] Figures 5 and 6 show a disk-shaped adaptor 51 which has a radial passage 52 which terminates in an axial passage 53. The adaptor is suitably secured to the end of the capillary tube 22 by collar 54. This prevents liquid droplets from directly entering the capillary passage, but permits ions and gas to be sucked into the input orifice 23 of the capillary 22 through the passages 52, 53. Figure 7 shows an adaptor with four radial passages 56 providing a greater flow of ions into the capillary 22. Figures 8 and 9 show an adaptor 57 which includes a slot 58 forming radial passages when the adaptor is secured to the capillary 22. Figure 10 shows an adaptor 49 with a bent tube 61 which provides flow of ions to the capillary 22.

[0015] The embodiments of Figures 5-10 all prevent direct entry of droplets and involatile material into the capillary orifice 25. The adaptor may be used when needed without requiring the replacement of the capillary in mass analysis systems which are normally used with samples having volatile buffers. Furthermore, the adaptors can be replaced if contamination does occur, rather than having to replace the whole heated capillary.

[0016] Thus there has been provided an ion transmission system including a capillary and an adaptor which prevents direct line of sight between the ion source and the capillary orifice, whereby the capillary orifice is not fouled by deposited salts from evaporated liquid droplets or involatile material from the ion source.

Claims

1. An ion transmission system for transferring ions from an atmospheric pressure ion source to a mass analyzer including:

   a capillary having an elongated axial capillary passage with its input orifice opposite the ion source;
   an adaptor configured to be secured to the end of the capillary and preventing direct line of sight from said orifice to said ion source whereby ions from said source are indirectly coupled to the input orifice while liquid droplets and involatile material are diverted away from the input orifice whereby fouling of said orifice is minimized.

2. An ion transmission system as in claim l in which said adaptor includes a disk supported between the ion source and the capillary orifice.

3. An ion transmission system as in claim 2 in which the disk is supported spaced from the orifice by a cup-shaped member supported from the capillary by a sleeve.

4. An ion transmission system as in claim 3 in which the cup-shaped support includes a slotted bottom allowing droplets and involatile material to pass through the adaptor.

5. An ion transmission system as in claim 1 in which said adaptor includes

a member having a passage in line with the orifice and a passage extending at an angle with respect to said passage whereby desolvated ions can pass through said passages to the capillary orifice while fluid droplets and involatile materials flow past the passage.

6. An ion transmission system as in claim 5 in which said adaptor includes a plurality of passages extending at an angle.

7. An ion transmission system as in claim 1 in which said adaptor includes a slotted disk adapted to be secured to the end of the capillary to define therewith a radial passage whereby desolvated ions pass through said passage to the orifice and fluid droplets and involatile material flows past the passage.

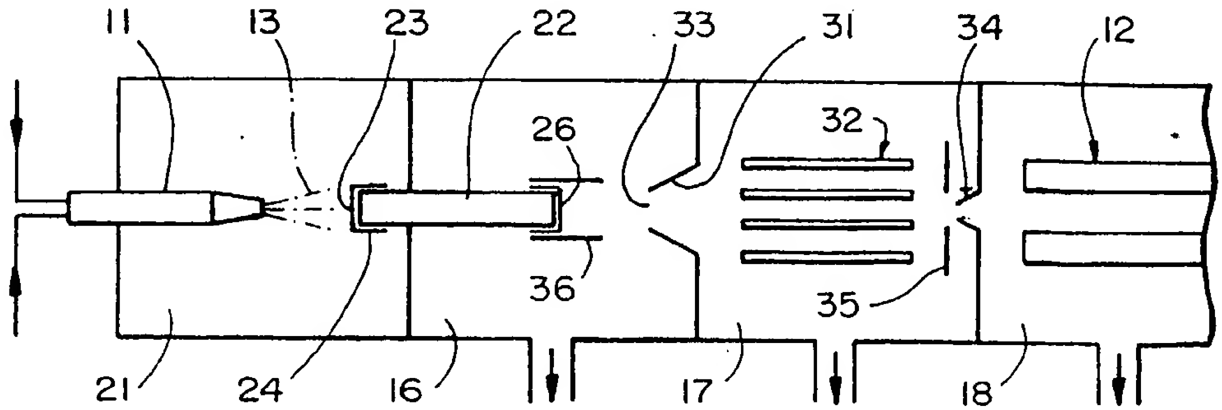

FIG_1
(PRIOR ART)

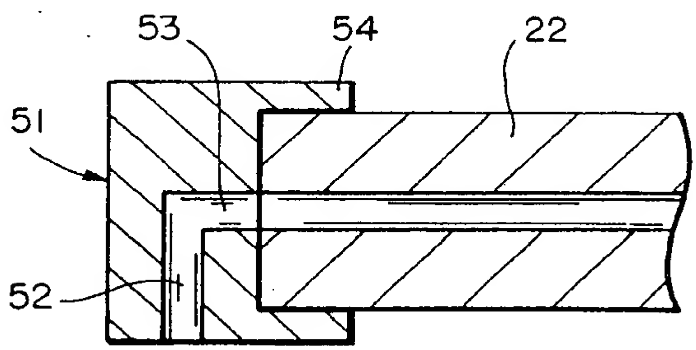

FIG_5

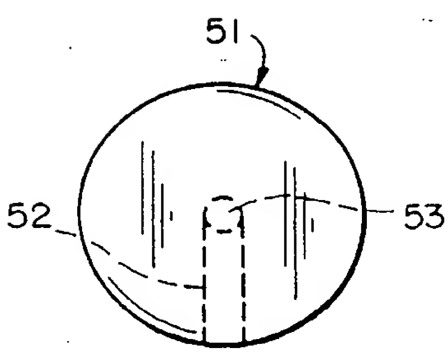

FIG_6

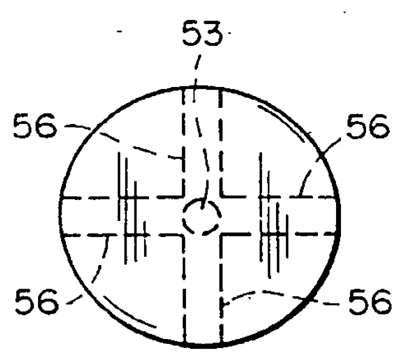

FIG_7

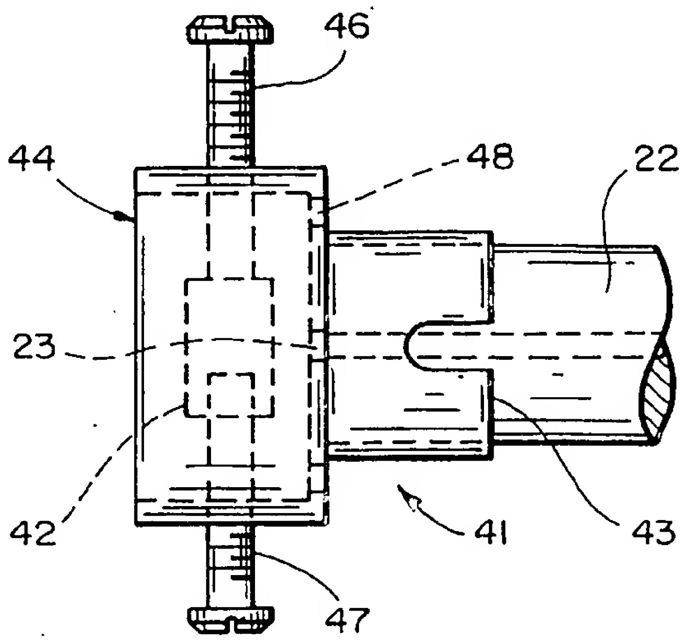

FIG_2

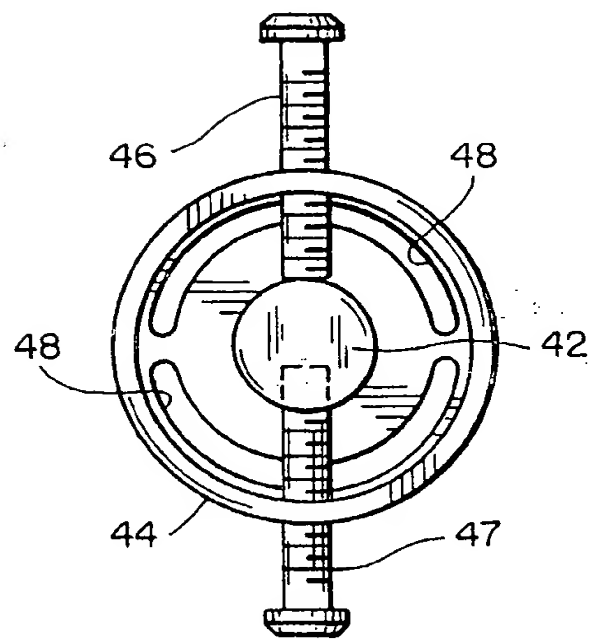

FIG_3

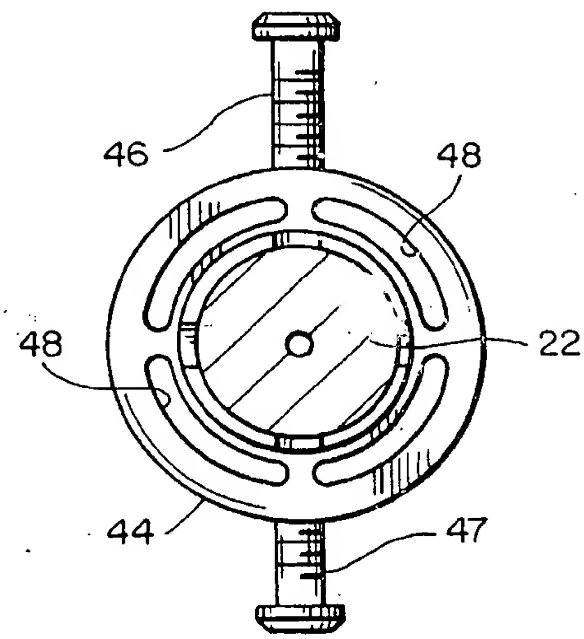

FIG_4

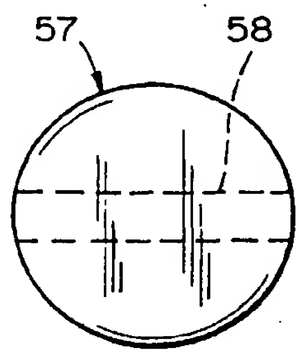

FIG_8

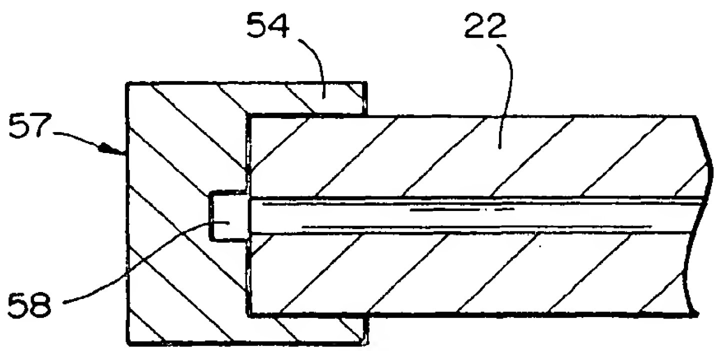

FIG_9

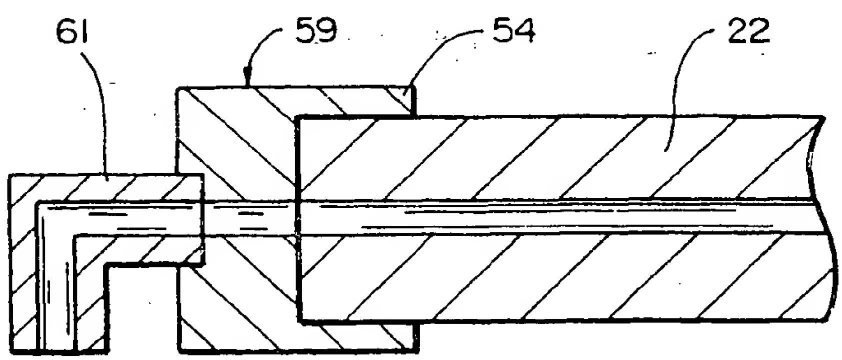

FIG_10